DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

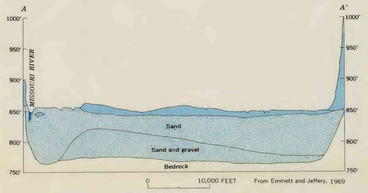
PREPARED IN COOPERATION WITH THE
MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES

HYDROLOGIC INVESTIGATIONS
ATLAS HA-444 (SHEET 2 OF 4)

GROUND WATER AVAILABILITY AND QUALITY

The aquifers of northwestern Missouri may be classified into two groups; (1) the unconsolidated aquifers (glacial drift and alluvium), and (2) the consolidated or bedrock aquifers. The unconsolidated aquifers are the most important sources of ground water in the area and these aquifers are emphasized in this atlas. Shallow consolidated aquifers yield small supplies of moderately mineralized water in local areas. Water from the deeper consolidated aquifers is more highly mineralized and these aquifers may increase in importance with future developments in desalinization and underground waste disposal.

UNCONSOLIDATED AQUIFERS



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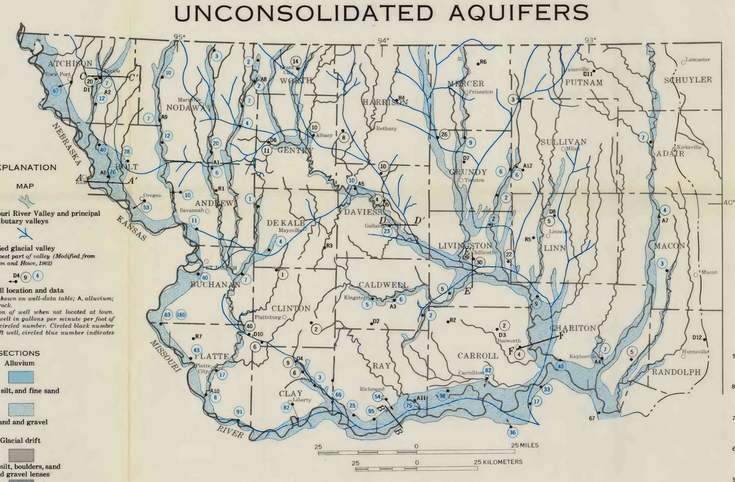
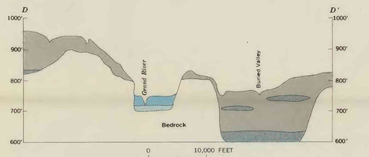
RULO SECTION





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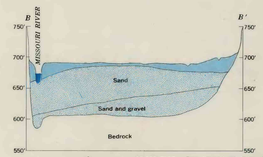
GALLATIN SECTION



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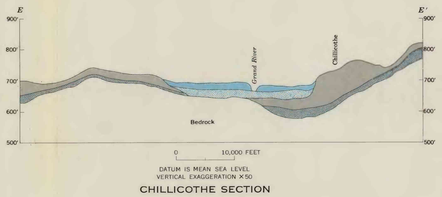
RICHMOND SECTION



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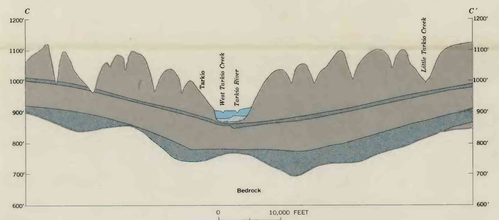
CHILLICOTHE SECTION



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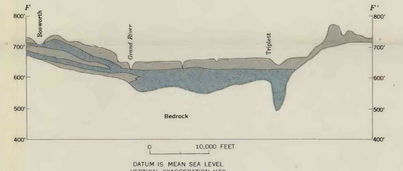
TARKIO SECTION



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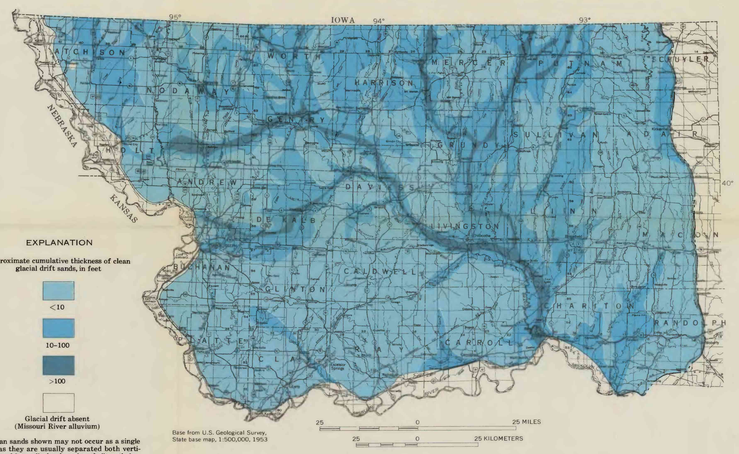
VERTICAL EXAGGERATION X50

BOSWORTH SECTION

THE PRINCIPAL SOURCES OF FRESH GROUND WATER IN NORTHWESTERN MISSOURI ARE THE ALLUVIUM OF THE MISSOURI RIVER VALLEY; THE ALLUVIUM OF TRIBUTARY VALLEYS; AND THE OUTWASH DEPOSITS IN BURIED BEDROCK VALLEYS.—*The existing drainage network has been developed on the unconsolidated materials overlying the buried bedrock valleys. Hydraulic connection between the alluvium of tributary valleys and the buried valleys is considered poor in most areas owing to the usual presence of relatively impermeable silt and clay deposits separating the two aquifers. However, toward the lower end of the Grand River valley the two aquifers may be separated by little or no fine material and hydraulic continuity would exist. Artesian conditions exist in most of the buried valleys and in some areas in the Missouri River valley and tributary valleys. The depth and lateral extent of the buried valleys generally exceed those of the modern tributary valleys as shown by the accompanying cross sections and glacial drift map.*

Well yields are smaller in the tributary and buried valleys than in the Missouri River valley. Tributary valley wells usually yield less than 100 gpm (gallons per minute) and buried valley wells less than 500 gpm, but may yield as much as 1,000 gpm in local situations. Wells located in the Missouri River alluvium are capable of yields of 1,000 to 2,000 gpm (Emmett and Jeffery, 1969).

The specific capacity of representative wells in the principal aquifers is indicative of the amount of drawdown to be expected in a well producing at a selected rate. For example, a well with a specific capacity of 10 gpm per foot of drawdown (typical of wells in tributary alluvium and buried valleys) will yield 100 gpm with 10 feet of drawdown and a well with a specific capacity of 80 gpm per foot of drawdown (typical of wells in Missouri River alluvium) will yield 800 gpm with 10 feet of drawdown.



FAVORABLE AREAS FOR DEVELOPING WELLS IN GLACIAL DRIFT ARE INDICATED BY THE PRESENCE OF CLEAN SANDS.—*The term clean sands refers to either sand or sand and gravel deposits which are relatively free of silt and clay. Due to the mode of deposition, these deposits are usually separated both vertically and laterally by deposits of silt or clay and well yields are generally less than might be expected for an equal thickness of clean sand occurring in a single continuous unit. The cleaner and coarser sands usually occur near the base of the glacial drift.*

In general, areas having 10 to 100 feet of clean glacial drift sands are capable of yields sufficient for rural domestic supplies (2–30 gpm) and areas having greater than 100 feet of clean sands are capable of yields sufficient for municipal, industrial, and irrigation supplies (20–500 gpm and occasionally as much as 1,000 gpm). Most favorable areas are the buried valleys.

Small quantities of water are obtained locally from shallow drift wells; however, such supplies are generally undependable and may be insufficient for current domestic needs. A notable exception is a rather poorly defined area in the vicinity of Lathrop in Clinton County where drift wells less than about 50 feet deep produce as much as 20 gpm.

WATER QUALITY

Water from the glacial drift is a mixed calcium bicarbonate-sodium sulfate type. The water is hard and high in iron, dissolved solids, and sulfate.

The dissolved-solids content of water from bedrock aquifers ranges from less than 1,000 to more than 20,000 mg/l and sodium chloride, and sulfate are usually the principal constituents

Water from the alluvial aquifers may be classified as a calcium bicarbonate type in most instances, although other types also occur. Alluvial water is hard and usually has a high iron content. Only two water analyses are presented in the following table for the Missouri River alluvium as more comprehensive tabulations for this aquifer are given by Emmett and Jeffery (1969a, 1969b, and 1970).

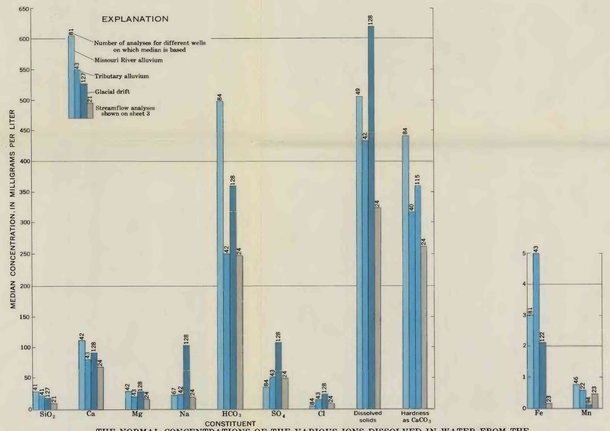
REPRESENTATIVE WELL DATA

[Analyses by Missouri Geological Survey and Water Resources and Missouri Division of Health]

Map number on above map	Well owner	Well location: County	Township	Range	Well characteristics: Total depth (feet)	Depth of casing (feet)	Water-bearing stratum[1]	Rate of pumping (gpm)	Specific capacity (gpm per foot of drawdown)	Date of collection	Water quality: Milligrams per liter: Silica (SiO2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO3)	Sulfate (SO4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO3)	Hardness as CaCO3: Dissolved solids (residue at 180° C)	Calcium, Magnesium	Noncarbonate	pH
ALLUVIUM																										
A1	Town of Bolckow	Andrew	3	61	35W	28	23	a	100	6	9-11-69	24	11	0.99	62	12	28	1.5	323	7.0	12	0.3	1.6	335	204	0	6.7
A2	Town of Tarkio	Atchison	13	65	40W	66	51	b	153	7	9-11-69	29	11	1.4	79	18	39	2.5	420	20	8.2	.2	.2	413	270	0	6.6
A3	Caldwell Co. Water Dist. No. 1	Caldwell	22	56	27W	50	45	e	150	6	9- 9-69	20	12	1.1	54	6.4	10	.8	223	7.0	5.2	.3	2.0	230	162	0	6.6
A4	Town of Keytesville, No. 2	Chariton	5	53	18W	40	25	d	130	7	10- 5-68	36	2.5	.45	49	15	88	3.0	214	32	137	.2	.2	601	175	9	7.4
A5	Town of Pattonsburg, No. 1	Daviess	35	61	29W	40	35	e	60	10	7-22-69	23	3.0	.29	112	18	34	2.1	126	243	48	.1	.8	585	160	196	6.4
A6	Big Lake State Park	Holt	30	61	39W	87	77	f	152	76	12- 8-66	24	1.0	.....	112	41	40	6.6	634	6	17	.3	.0	608	448	0	7.3
A7	Town of Elmer	Macon	2	59	16W	48	43	g	30	4	6- 6-69	16	.4	0	114	25	118	1.0	418	197	46	.2	.2	845	343	45	7.4
A8	Town of Parnell, No. 1	Nodaway	8	65	33W	23	18	h	27	2	7-23-69	27	10	.98	95	12	27	1.9	317	91	9.2	.1	.0	436	260	19	7.1
A9	Town of Skidmore, No. 3*	Nodaway	9	63	37W	37	27	i	80	7	11-17-61	20	18	.....	59	10	22	.....	236	23	15	.....	.....	460	190	0	6.7
A10	Platte Co. Water Dist. No. 1	Platte	33	52	35W	63	58	h	150	8	4- 1-69	24	6.0	.3	103	33	8.5	4.6	455	52	4.5	.2	.2	533	374	18	8.0
A11	Town of Hardin	Ray	32	52	26W	83	71	f	170	75	4-19-67	24	5.0	.35	147	31	30	5.6	465	111	50	.1	.2	683	382	112	6.8
A12	Town of Humphreys, No. 1	Sullivan	26	62	22W	28	23	j	64	6	7- 3-69	23	5.8	.61	74	17	23	1.5	240	106	7.2	.1	.0	413	196	59	6.9
GLACIAL DRIFT																										
D1	Town of Tarkio	Atchison	14	65	40W	209	164	S	320	20	9-27-57	32	0.6	0	82	27	159		334	255	95	0.1	5.8	922	316	42	8.2
D2	Town of Polo	Caldwell	27	55	28W	65	.....	S	13	.....	9- 9-69	26	1	.10	155	46	70	1.5	418	307	47	.4	37	1,035	342	236	7.0
D3	Town of Tina, No. 1	Carroll	35	53	23W	48	43	S	30	2	7- 1-69	26	27	.89	64	12	74	4.9	485	4.2	13	.1	3.9	497	210	0	6.9
D4	Clay Co. Water Dist. No. 3	Clay	15	53	31W	63	53	S, G	100	9	9-11-69	28	7.9	1.7	74	8.6	14	.8	257	16	24	.2	.0	301	211	9	6.1
D5	Town of Jamesson, No. 1	Daviess	18	60	27W	92	87	S, G	20	4	7-22-69	20	1.6	.07	80	27	52	2.9	532	15	2.7	.3	.0	472	310	0	7.4
D6	Town of Stanberry	Gentry	31	63	29W	220	210	S, G	100	11	10-24-66	24	4	.....	122	43	320	12	453	600	113	.5	1.8	1,140	370	110	7.3
D7	Herman Marriott	Grundy	28	62	24W	127	127	S	5	.....	7-15-69	29	4.3	.09	265	51	87	4.2	422	513	14	.3	.2	1,233	346	375	7.8
D8	Linn Co. Water Dist. No. 1	Linn	36	60	21W	78	68	S, G	125	5	9- 8-69	24	5.3	.36	75	12	38	1.4	269	90	4.7	.3	.0	401	236	0	7.1
D9	Town of Chillicothe	Livingston	2	57	24W	162	76	S, G	740	30	1-20-69	24	1.5	.2	113	18	40	2.0	461	64	12	0	0	526	358	0	6.9
D10	Town of Edgerton, No. 2	Platte	6	54	33W	80	75	S, G	60	40	9-16-69	39	30	4.0	96	11	10	1.4	337	35	5.7	0	.04	349	276	11	6.2
D11	Sid Morrow	Putnam	25	67	19W	227	.....	S	.....	.....	3-15-56	9.3	13	.05	104	37	312	.05	301	737	25	1.0	5.8	1,449	247	165	7.7
D12	T. D. Dickerson	Randolph	2	54	14W	142	.....	S	.....	.....	3-15-66	10	1.7	.22	85	40	81	.22	381	16	12	.1	12	548	380	0	7.6
BEDROCK																										
R1	Ralph Eckler	Andrew	11	60	35W	189	.....	P	.....	.....	6-24-57	6.0	0.3	0.00	76	30	607		416	396	502	1.4	1.4	1,817	315	0	7.6
R2	Rudolph Kruse	Carroll	16	53	23W	495	.....	.....	.....	.....	5- 8-57	6.5	3.4	.05	322	158	3,324		469	1,073	5,000	1.4	.1	10,277	392	3,061	7.4
R3	Hugh Swords	DeKalb	28	58	30W	425	.....	.....	.....	.....	11-20-56	5.3	3.8	.17	96	47	1,632		452	216	2,348	.6	6.2	4,589	398	33	8.2
R4	Town of Ridgeway	Harrison	3	64	27W	1,178	.....	P, M	.....	.....	10-20-64	6.0	1.5	.00	466	1,704	1,150	1.8	.0	4,914	356	0	7.3			
R5	R. E. Dolan	Linn	5	58	21W	565	.....	.....	.....	.....	2- 5-57	5.5	3.4	.05	84	46	2,397		418	988	3,060	1.4	.1	6,787	391	6	7.6
R6	Mercer Public School	Mercer	20	66	23W	450	265	P	5	.04	1- 5-56	6.5	2.7	.00	41	29	744	3,243	313	278	1.6	.0	2,011	1,080	0	7.9
R7	John Gaskill	Platte	13	54	36W	460	.....	.....	.....	.....	4- 7-51	4.0	30	.....	84	40	3,757		347	39	5,747	.....	.....	9,768	284	89	7.6

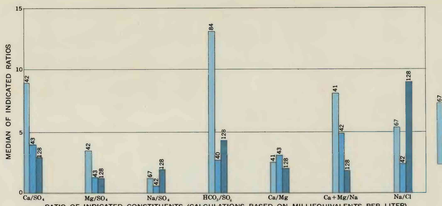
[1] ALLUVIUM: a, Ore hundred and Two River alluvium; b, Tarkio River alluvium; c, Shoal Creek alluvium; d, Mussel Fork alluvium; e, Grand River alluvium; f, Missouri River alluvium; g, Chariton River alluvium; h, Platte River alluvium; i, Nodaway River alluvium; j, Medicine Creek alluvium. GLACIAL DRIFT: G, gravel; S, sand. BEDROCK: M, Mississippian; P, Pennsylvanian.

[2] Well characteristic data applies to Skidmore No. 2; water-quality data applies to Skidmore No. 2.



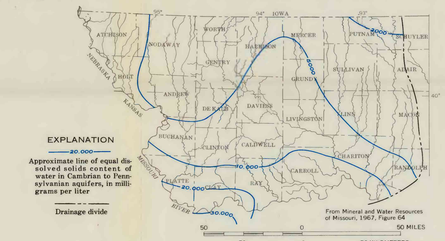
THE NORMAL CONCENTRATIONS OF THE VARIOUS IONS DISSOLVED IN WATER FROM THE PRINCIPAL AQUIFERS IS REFLECTED BY MEDIAN CONCENTRATIONS BASED ON A LARGE NUMBER OF ANALYSES.—*The concentrations shown are representative of the area as a whole and individual analyses may vary significantly from these values.*

Concentrations of the various ions in water collected from tributary streams during periods of low flow are similar to those in water from tributary alluvium although altered in several areas by the addition of municipal sewage effluent.

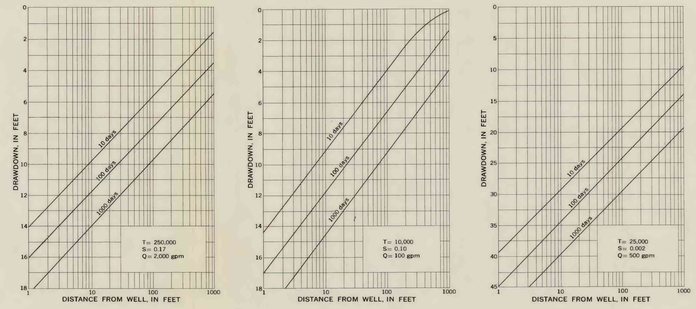


WATER FROM THE PRINCIPAL FRESH-WATER SOURCES HAS SLIGHTLY DIFFERENT CHEMICAL CHARACTERISTICS.—*Higher ratios of calcium:sulfate, magnesium:sulfate, bicarbonate:sulfate, and calcium + magnesium:sodium can be expected in water from the Missouri River alluvium than in water from tributary alluvium or glacial drift. While some generalizations can be made about the chemical characteristics of water from the three principal aquifers on the basis of concentrations, ratios of one constituent to another provide a means of determining whether water from several sources is mixing in some localities. For example, in comparing the chemical characteristics of the water in the drift-filled channel at Chillicothe where it underlies the Grand River alluvium (see section EE' above) ratios show that water in the alluvial aquifer has some of the characteristics of water in the glacial drift. Water in the drift-filled channel at Chillicothe is dissimilar to water in other drift channels not closely related to an alluvial valley.*

On the Missouri River flood plain where all wells pump water from the alluvium, ratios show the effect of (1) mixtures with water in a drift-filled channel beneath the alluvial deposit in the Kansas City and St. Joseph areas; (2) possible induced infiltration from the Missouri River in the Kansas City area, and (3) the alteration of ground water on the north side of the valley by contribution from the glacial drift and south flowing tributary streams.



WATER FROM BEDROCK AQUIFERS IN NORTHWESTERN MISSOURI IS GENERALLY TOO HIGHLY MINERALIZED FOR MOST USES.—*Mineralization varies both areally and with depth and the dissolved-solids content usually exceeds 1,000 mg/l. A marked increase occurs in the dissolved solids from the Iowa line to the Missouri River area. However, the lines represent a composite of the Cambrian to Pennsylvanian section and within the area, shallow wells in Pennsylvanian sandstones may yield small quantities of water having less than 1,000 mg/l of dissolved solids.*



THE LOCATION AND SPACING OF WELLS IN THE THREE PRINCIPAL AQUIFER SYSTEMS OF NORTHWESTERN MISSOURI SHOULD BE BASED ON THE AMOUNT OF WATER NEEDED AND THE CHARACTERISTICS OF THE AQUIFER.—*Although considerable variation in values of T (coefficient of transmissibility) and S (coefficient of storage) exists in each of the three aquifers, time-distance-drawdown graphs based on typical values of T, S, and Q (discharge) indicate that for a specified quantity of water the spacing of wells can be much closer in the Missouri River valley than in the tributary or buried valleys.*

For example, the drawdown will be about 5.5 feet in a well in the Missouri River alluvium located 1,000 feet from a second well which has been producing steadily for 1,000 days at a rate of 2,000 gpm. If the rate of pumping had been 100 gpm for the same period of time the drawdown at a distance of 1,000 feet would have been only about one-twentieth of 5.5 or about 0.3 feet. A well in a typical tributary valley, however, can be expected to show a decline of about 1 feet in water level when located at a distance of 1,000 feet from a well which has been producing at a rate of 100 gpm for a period of 1,000 days.

As the glacial outwash deposits of the buried valleys are generally under artesian pressure lower values of S can be expected in the buried valleys than in tributary valleys. In buried valleys for example, after 1,000 days of steady pumping at a rate of 500 gpm the water-level decline 1,000 feet away can be expected to be about 10 feet. At a pumping rate of 100 gpm the drawdown would be about one-fifth of 10, or about 1 feet, approximately the same as for a tributary valley well.

Because of induced infiltration, the amount of drawdown can be expected to be less than the values shown for wells located near the Missouri River or tributary streams. Wells located near valley walls, however, may have greater amounts of drawdown because of discharge boundary conditions. Because of the variability of aquifer characteristics in the area, aquifer tests should be made before final design of well fields.

AQUIFER EVALUATION

[Shaded area includes most favorable aquifers. A small area of Permian rocks occurs in Atchison County and is not considered in this table]

System	Series	Geologic unit	Thickness (feet)	Lithology	Water-bearing properties and water-quality characteristics
Quaternary	Holocene	Alluvium: Tributaries	0–60	Sand, gravel, clay, silt.	Permeable deposits 0 to 30 feet thick overlain by 5 to 30 feet of clay and fine sand. Yields range from 10 to 175 gpm but usually do not exceed 100 gpm. Highest yields occur along the Grand, Chariton, Nodaway, and lower Platte Rivers. Highest specific capacities along Grand River, lowest along the upper Platte River. Specific capacities range from 2 to 23 gpm per foot of drawdown. Yields are limited by shallow depth and small thickness of aquifer. Water has high iron content, which can be lowered by aeration.
		Alluvium: Missouri River	0–150	Sand, gravel, boulders, clay, silt.	Permeable deposits as much as 100 feet thick. Wells capable of yields of 1,000 to 2,000 gpm and have specific capacities of as much as 150 gpm per foot of drawdown. Iron present but generally does not average as high as that in tributary stream deposits.
	Pleistocene	Glacial Drift	0–400	Sand, gravel, clay, silt, boulders.	Permeable deposits may exceed 100 feet in thickness, but high yield wells are completed in 20 to 40 feet of very permeable sand and gravel. Yields and specific capacities are as high as 800 gpm and 40 gpm per foot of drawdown, respectively, from wells drilled in buried valleys. Yields and specific capacities may be as low as 5 gpm and 0.5 gpm per foot of drawdown, respectively, from wells in areas between buried valleys. Iron content is usually lower than that of alluvium, but water is more mineralized. Highly mineralized water from glacial drift may be derived in part from underlying Pennsylvanian sandstone.
Pennsylvanian			0–1, 800	Limestone, sandstone, shale, and coal.	Well yields for domestic water supplies are small from sandstones, and a few small springs issue from Pennsylvanian limestone. Dissolved solids range from less than 1,000 mg/l to more than 20,000 mg/l. Most water has more than 1,000 mg/l.
Mississippian Devonian Silurian Ordovician Cambrian			1, 500–2, 400	Limestone, dolomite, shale, and sandstone.	Unimportant as a source of fresh water but may be important for future consideration in desalinization and waste disposal. It has been suggested (Mineral and Water Resources of Missouri, 1967 p. 296) that the yield of the lower Ordovician and Cambrian aquifers may compare favorably with the yields obtained in the bordering freshwater area in Central Missouri.
Precambrian				Igneous and metamorphic rocks.	Unimportant as a source of water.

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WATER RESOURCES OF NORTHWESTERN MISSOURI

By
E. E. Gann, E. J. Harvey, and J. H. Barks
U.S. Geological Survey
and
D. L. Fuller
Missouri Geological Survey and Water Resources

1973